AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraphs beginning on pages 1, line 21, and continuing to page 2, line 27, as follows:

In WCDMA, fast power control is standardized for both up- and downlink ~~[1]~~. 3GPP, Physical layer procedures (FDD), Technical Specification TS 25.214. The user equipment (UE) sends transmitter power control (TPC) commands, i.e. 'power up' or 'power down' indications, to the network. These commands are used in the base station to update the dedicated power of the UE. The default algorithm is to step-wise update the power, using the TPC command to define whether the new power value is to be the previous power value plus or minus a fixed power step size. Provided that saturation does not occur, the power control command is always granted. There are two options associated with the default power control algorithm, the first of which reduces the risk of misinterpreted TPC commands, and the second limits the power raise of the power control through a sliding window size and a threshold.

The standardized power control algorithms in 3GPP are primarily designed for situations when it is possible to fulfil all service requirements and the mutual interference can be compensated for. However, since the radio environment is time varying, situations may arise where there is not sufficient carrier power in the base station to fulfil the service requirements of all users and there is a risk for unstable system behavior ~~[2]~~. Gunnarsson, F. and Gustafsson, F., Power Control with Time Delay Compensation, *Proc. Vehicular Technology Conference*, Boston, MA, USA, September 2000. Wireless communication systems are generally provided with means for admission control and means for disconnecting services, but these are relatively slow and not designed for handling system instabilities. Therefore, there is a need for mechanisms that are able to handle this on a small time scale with fast actions.

Several alternative power control algorithms have been proposed. In US Patent 5,574,982 to Almgren, et. al.~~[3]~~, for example, a quality target is gradually reduced when the dedicated channel power is increased. Essentially, this means that users requiring high powers have to put up with lower quality.

~~The i~~International patent application WO 02/35731 A1~~[4]~~ addresses the problem of diverging transmitter output power levels of two or more base stations with respect to a mobile station in macro-diversity communication. The respective base station transmitter output powers for the mobile station are adjusted in response to the power control instructions from the mobile station and the respective current base station transmitter output powers for the mobile station. The adjustments can be performed in fixed or continuous steps.

Step size adjustments based on TPC history, mobility speed and bit error rate (BER) probability is e.g. described in the following documents~~ [5], [6] and [7]~~: International Patent Application WO 00/04649; European patent application EP 0 815 656 B1; and US Patent 6,311,070 B1.

Please amend the paragraphs beginning on page 3, line 8, and continuing to page 4, line 2, as follows:

A ~~general object of the present invention is to provide a~~ method for downlink power control that improves the stability of wireless communication systems~~. A specific object is to achieve~~ and achieves efficient utilization of power resources in communication systems with shared resources. ~~Another object is to~~The method eliminates the risk of temporary running out of transmitter power~~. Still another object is to provide~~, and provides a power control mechanism suitable for WCDMA systems.

~~These objects are achieved in accordance with the attached claims.~~

Briefly, ~~the present invention proposes~~an example method involves an overall approach to downlink power control. In response to a transmitter power change request from a mobile terminal, a base station determines a power control parameter, such as a maximum connection-specific transmitter power, a power step size, or a power increase probability, based on its current total transmitter power. The power control parameter is then used by the base station to distribute transmitter power to the connection. By considering all connections associated with the base station (and not only the connection that is controlled) when allocating transmitter power to an individual connection, a more efficient power control method is achieved and the risk of overallocation can be eliminated.

In some advantageous example embodiments~~ of the invention~~, power control is performed using the current total transmitter power together with other input parameters related to a connection-specific code power and/or information indicating the degree of priority associated with the connection.

According to other example aspects of the ~~invention~~technology, a transceiver node, and a communication system are provided.

Please amend the paragraphs beginning on page 4, line 11, and continuing to page 4, line 30, as follows:

Fig. 1 is a schematic overview of an exemplary WCDMA communication system ~~in which the present invention can be used~~;

Fig. 2 illustrates downlink power control messaging in accordance with ~~the present invention~~an example embodiment;

Fig. 3 is a flow chart of a method for downlink power control according to an example preferred embodiment ~~of the present invention~~;

Fig. 4A-B are diagrams illustrating code power and code power increase obtained with conventional power control;

Fig. 5A-C are diagrams illustrating power increase probability, code power and code power increase in accordance with an exemplary embodiment ~~of the present invention~~; and

Fig. 6 is a diagram illustrating the relation between a power control parameter, code power and carrier power in accordance with an exemplary embodiment ~~of the present invention~~.

Please amend the paragraph beginning on page 5, line 3, and continuing to page 5, line 14, as follows:

Fig. 1 is a schematic overview of an exemplary WCDMA communication system in which the present ~~invention~~ technology can be used. The illustrated system 100 comprises a Radio Access Network (RAN), e.g. a Universal Terrestrial Radio Access Network (UTRAN), and a core network 130. The RAN performs radio-related functions and is responsible for establishing connections between user equipment 110, such as mobile phones and laptops, and the rest of the network. The RAN typically contains a large number of Base Transceiver Stations (BTS) 122, also referred to as Node B, and Radio Network Controllers (RNC) 124. Each BTS serves the mobile terminals within its respective coverage area and several BTS are controlled by a RNC. Typical functions of the RNC are to assign frequencies, spreading or scrambling codes and channel power levels.

Please amend the paragraph beginning on page 5, line 29, and continuing to page 6, line 5, as follows:

The present ~~invention~~ technology is well suited for and will primarily be described in connection with WCDMA communication, for example High-speed Downlink Shared Channel (HS-DSCH) systems. Nevertheless, it should be understood that other communication systems where multiple users can utilize the same power resource simultaneously also lie within the scope of the ~~invention~~technology. Systems where the power utilization of a node affects adjacent nodes due to high interference are also suited for the ~~invention~~technology. Such systems for instance include time-multiplexed or code-multiplexed Orthogonal Frequency Division Multiplexing (OFDM) and Time Division Multiple Access (TDMA) systems and systems using Multi Carrier Power Amplifiers (MCPA).

Please amend the paragraph beginning on page 6, line 15, and continuing to page 7, line 1, as follows:

As mentioned in the background section, fast power control (1500Hz) is in WCDMA standardized for both up- and downlink. The UE sends a transmitter power control command *TPC(t)* to the network 1500 times per second, and each command states either 'power up' or 'power down'. This command is used in the base station to update the dedicated power of the UE *p(t)*. The 3GPP standardized downlink power control algorithms include one default algorithm with two options, 3GPP, Physical layer procedures (FDD), Technical Specification TS 25.214~~[1]~~. The default algorithm is to step-wise update the power *p(t)* in logarithmic scale (in dB) every slot *t*, using the received transmitter power control command *TPC(t)*, which is either +1 or -1 according to:

$$p(t+1) = p(t) + \Delta * TPC(t) \quad [\mathrm{dB}] \qquad (1)$$

where Δ is the step size in dB. The step size Δ can have four values: 0.5, 1, 1.5 or 2 dB. It is mandatory for UTRAN to support a step size of 1 dB, while support of other step sizes is optional. The only reason for not granting the power control command is if the power saturates, i.e. the power meets the upper or lower limitations (*p_upper* and *p_lower* respectively), which are parameterized by the operator. This implies that:

$$p(t+1) = \max(p\_lower, \min(p\_upper, p(t) + \Delta * TPC(t))) \quad [\text{dB}] \qquad (2)$$

Please amend the paragraphs beginning on page 7, line 13, and continuing to page 7, line 29, as follows:

The present ~~invention~~ technology is based on the recognition that a most efficient downlink power control can be obtained by changing the power dedicated to a respective connection in response to the total transmitter power situation. The total transmitter power of the base station is a limited resource and it is therefore desirable to control the system with regard to this parameter. By measuring the total transmitter power of the base station and by controlling the system based thereon ~~according to the invention~~, a power control mechanism that directly responds to the most crucial power parameter can be achieved.

In order to enhance the system stability the present ~~invention~~ technology thus proposes an overall control approach where downlink power control is based on the total transmitter power of the base station. This will now be further described with reference to Fig. 2, in which a transceiver node 122 and two mobile terminals 110 are shown. The transceiver node is capable of communicating with the mobile terminals over respective wireless connections.

Please amend the paragraph beginning on page 8, line 26, and continuing to page 8, line 33, as follows:

Also indicated in the figure are transmitter (downlink) powers p_i for each connection i, also referred to as the downlink code power of a respective connection. The current connection-specific transmitter power $p_i(t)$ represents the downlink power allocated to connection i by the base station at a particular point of time t. By default, the code power allocation is performed according to the power control algorithm of Eq. (1), but according to the present ~~invention~~ technology this power allocation is handled in an improved way that will now be described.

Please amend the paragraph beginning on page 9, line 15, and continuing to page 9, line 21, as follows:

Fig. 3 is a flow chart of a method for downlink power control summarizing the main principles of a preferred example embodiment ~~of the invention~~. In step S1, a transmitter power change request from a mobile terminal is received at a base station over a wireless connection. This request can for example comprise a standard WCDMA TPC command and the ~~invention~~ technology is applicable to both increase and decrease commands. In particular, it is useful for handling situations with repeated power increase commands.

Please amend the paragraphs beginning on page 10, line 18, and continuing to page 12, line 11, as follows:

By means of the present ~~invention~~technology, the behavior of respective connections is adjusted depending on the behavior of the entire shared power resource. Conventional methods for downlink power control focuses entirely on individual connections. Since the mobile terminal does not have any knowledge about the power

situation for other links, this implies a considerable risk of overallocating or temporary running out of transmitter power. By instead considering the power behavior of other connections to/from the base station through the total power resource, including the power common for all (or a subset of the) links, the invention offers a more efficient power control mechanism. A major advantage is that it can be used to ensure that no attempts are made on the network side to allocate more power resources than available. Hence, the risk of temporary running out of transmitter power can be eliminated, resulting in a preserved system stability.

Another advantage of the ~~invention~~ technology is that it enables a smooth response to power increase requests from the user equipment. The allocated power can be made to rise smoothly when the maximum transmitter power is approached, which leads to a more controlled behavior of the base station transmitter power. The control is preferably performed on a comparatively small time scale, which results in fast adjustments as the overall power situation changes.

By performing power control at the network side and considering the overall power situation for the base station, the present ~~invention~~ technology thus improves the system stability. The improved stability in turn results in an enhancement of both the capacity and the quality of the services experienced by the users. Wireless communication systems in general are associated with trade-offs between coverage, quality and load. Hereby, a key issue is to balance service coverage against system stability, i.e. optimize the resource (base station downlink powers) utilization, such that a good service coverage is obtained at low loads and a good system stability is obtained at high loads. The present ~~invention~~ technology enables the above factors to be properly balanced, e.g. by reducing the coverage or providing a soft degeneration of the quality when the load increases.

According to a particularly advantageous example embodiment ~~of the invention~~, the power control parameter is determined by a combination of the total transmitter power (downlink carrier power) of the base station and the connection-specific transmitter power (downlink code power). The power control is then related to the connection-specific resource utilization in addition to the overall resource utilization of all links. Thereby, power saturation can be avoided and besides the smooth transitional behavior at high total transmitter powers (i.e. close to $P_{DL,max}$) it is also possible to make distinctions between different connections. Connections using a lot of code power can for example be "punished" through stronger power restrictions. Moreover, this solution is normally easy to implement and does not require any additional signaling (e.g. between RNC and Node B in WCDMA) since both the carrier power and the code power can be measured at the base station.

The means for imposing power restrictions ~~according to the invention~~ are preferably to adapt the maximum dedicated code power $p_{i,max}$; to state a probability π_i of granting a power change request command; and/or to adapt the power step size Δ_i. Exemplary embodiments ~~of the invention~~ with power control by means of each of these respective power control parameters will now be described. The exemplifying power control algorithms work for values both in linear [W] and logarithmic scale [dBW or dBm], but values in linear scale will be assumed if nothing else is stated.

Please amend the paragraphs beginnings on page 12, line 23, and continuing to page 12, line 33, as follows:

In a first example reflected by Equation (4), the maximum dedicated code power can vary from $p_{max,lower}$ to $p_{max,upper}$, and depends linearly on the downlink carrier power, when the latter is greater than $P_{DL,low}$ and less than $P_{DL,max}$. Otherwise, $p_{i,max} = p_{max,\ upper}$.

$$p_{i,max} = p_{max,upper} - (p_{max,upper} - p_{max,lower}) * (P_{DL} - P_{DL,low})/(P_{DL,max} - P_{DL,low}) \qquad (4)$$

A second example reflected by Equation (5) presents a simpler method where the maximum dedicated code power can have two different values depending on whether the carrier power is below a threshold $P_{DL,low}$ or not.

$$p_{i,\max} = \begin{cases} p_{\max,upper} & P_{DL} < P_{DL,\mathrm{low}} \\ p_{\max,lower} & P_{DL} \geq P_{DL,\mathrm{low}} \end{cases} \qquad (5)$$

Please amend the paragraph beginning on page 13, line 11, and continuing to page 13, line 17, as follows:

In the default power control algorithm in WCDMA, the base station increases the dedicated channel power by a step Δ upon receiving a transmitter power up command from the wireless unit. Only the maximum dedicated code power $p_{i,max}$ can hinder the power increase due to be granted. According to a preferred example embodiment ~~of the invention~~, grant of a received power up command is instead associated with an assigned probability $\pi_{inc,i}$ (possibly zero), referred to as a power increase probability.

Please amend the paragraphs beginning on page 14, line 1, and continuing to page 15, line 30, as follows:

Fig. 4 and 5 illustrate load-based downlink power control ~~according to the invention~~ with power increase probability as power control parameter as compared with conventional default power control. Fig. 4A-4B show the prior-art code power behavior for a connection to a wireless unit that is consistently asking for more power. The base station allocates power to the connection in accordance with the standardized control

algorithm of Eq. (1) and (2). Fig. 4A contains normalized code power values for the respective time slots, whereas Fig. 4B shows the power changes since the last slot. The diagrams clearly show the linear scale effects of the logarithmic scale power control (1). The power upsteps in Watt increase exponentially as the code power of the connection increases (before saturation at slot 30). This constitutes an instabilizing property of the conventional power control algorithm.

The dramatic increase can be made more graceful using the load based power control of the present ~~invention~~technology. Fig. 5A shows power increase probability according to equation (7) with n=2. Fig. 5B-5C corresponds to Fig. 4A-4B but this time the power control is performed based on P_{DL} and code power through the power control probabilities of Fig. 5A. The power increase probability decreases as the code power and carrier power increases, and this in turn makes the power control more graceful while approaching the maximum code and carrier powers.

A second example reflected by Equation (8) presents a simpler method where the power increase probability switches between 1 and another fixed value $\pi_{inc,lower}$ depending on whether the carrier power is below $P_{DL,\,low}$ or not.

$$\pi_{\mathrm{inc},i} = \begin{cases} 1 & P_{DL} < P_{DL,\mathrm{low}} \\ \pi_{\mathrm{inc},lower} & P_{DL} \geq P_{DL,\mathrm{low}} \end{cases} \qquad (8)$$

When most of the downlink code power is allocated, there are good reasons for being more careful with increasing the power. As mentioned above, an advantageous example embodiment ~~of the invention~~ performs power control based on both the total transmitter power of the base station and the connection specific transmitter power. Applied to the case where the power increase probability is used as power control parameter, this means that the power increase probability is a function of both the

downlink carrier power and the downlink code power: $\pi_{inc,\,i} = f(P_{DL}, p_i)$. In such a case, a higher downlink code power generally implies a lower power increase probability. In an exemplifying embodiment reflected by Equation (9), the aggregated power increase probability is the product of the power increase probabilities computed separately using downlink carrier power and the downlink code power :

$$\pi_{inc,\,i,\,aggregate} = \pi_{inc,\,i,\,PDL} * \pi_{inc,\,i,\,pi} \tag{9}$$

The second example reflected by Equation (11) uses a simpler method where the power increase probability switches between 1 and another fixed value $\pi_{inc,lower}$ depending on whether the carrier power is below p_{low} or not.

$$\pi_{\text{inc},i} = \begin{cases} 1 & p_i < p_{\text{low}} \\ \pi_{\text{inc},lower} & p_i \geq p_{\text{low}} \end{cases} \tag{11}$$

Other power control algorithms where the total transmitter power is used as an input together with one or several other inputs are possible. When more than one input are used, each input can be used to compute the power increase probability, and the aggregate of these computed values is used as the power increase probability. In an example with three different inputs, the aggregate is computed according to Equation (12). Inputs 2 and 3 can (but do not have to) include the connection-specific transmitter power.

$$\pi_{inc,\,i,\,aggregate} = \pi_{inc,\,i,\,PDL} * \pi_{inc,\,i,\,input\ 2} * \pi_{inc,\,i,\,input\ 3} \tag{12}$$

Please amend the paragraph beginning on page 16, line 7, and continuing to page 16, line 14, as follows:

The present ~~invention~~ technology instead proposes to adapt the power control step Δ in response to the total downlink power at the base station: $\Delta_i = f(P_{DL})$. The size of the power change (upward or downward) may be either decreased or increased. A power increase request from the mobile terminal may even result in zero or negative values of Δ, thus corresponding to a refused increase command. Since only the upward steps are critical for downlink stability, it can sometimes be preferred to limit the step size adaptation to upward steps, while letting the downward steps remain constant.

Please amend the paragraphs beginning on page 16, line 20, and continuing to page 17, line 15, as follows:

When most of the downlink carrier power is allocated, one should be careful with increasing the power entirely conformant to the power increase commands. With power control according to the ~~invention~~present technology, a higher downlink carrier power generally results in a lower upward step size. In an exemplifying embodiment the upward step size depends linearly on the downlink carrier power and decreases to zero when the carrier power approaches its maximum level. This is illustrated by equation (13) where Δ_{param} is a parameter and Δ_{norm} is the maximum power step size.

$$\Delta_i = \min(\Delta_{norm}, \Delta_{param} (P_{DL,max} - P_{DL})/ P_{DL,max}) \qquad (13)$$

Moreover, in some cases it can be motivated to use different steps upwards and downwards. Longer steps upward and shorter steps downward at low loads, and vice versa. In an exemplifying embodiment the upward and downward step sizes are separately adjusted and depend linearly on the downlink carrier power. The upward step

decreases to zero when the carrier power approaches its maximum level, while the downward step decreases to zero at low carrier powers. This is illustrated by Equations below (14), where Δ_{param} is a parameter, Δ_{norm} is the maximum power step size and $P_{DL,lower}$ is parameter indicating the lower carrier power level.

$$\Delta_{i,\ upward} = \min(\Delta_{norm},\ \Delta_{param}\ (P_{DL,max} - P_{DL})/\ P_{DL,max}) \qquad (14)$$

$$\Delta_{i,\ downward} = \min(\Delta_{norm},\ \Delta_{param}\ (P_{DL} - P_{DL,lower})/\ (P_{DL,max} - P_{DL,lower}))$$

As for the previously described control parameters, more than one input can be used to determine the step size. Hereby, each input can be used to calculate a respective step size, and the aggregate of these preliminary step size values is used as the step size through which the power control is effectuated. In an exemplifying embodiment with two different inputs, the aggregate is computed according to Equation (15).

$$\Delta_{i,\ aggregate} = \min(\Delta_{i,\ input\ 1},\ \Delta_{i,\ input\ 2}) \qquad (15)$$

Please amend the paragraph beginning on page 19, line 15, and continuing to page 19, line 26, as follows:

According to another preferred example embodiment~~ of the invention~~, the downlink power control is based on a combination of the total transmitter power and the degree of priority associated with the respective connections. The main idea is to avoid a situation where all connections experience unsatisfactory quality of service by adopting a proactive strategy to penalize some connections to save others. The power control parameters used to distribute transmitter power to a particular connection are in this case determined based on the total transmitter power together with connection-specific information indicating the degree of priority associated with the connection. The connection-specific information preferably comprises one or more so-called degree of

priority indicators DPI. Hence, the power p_i dedicated to connection i depends on P_{DL} and the DPI parameter for the connection DPI_i.

Please amend the paragraphs beginning on page 21, line 9, and continuing to page 21, line 123, as follows:

By performing downlink power control based on a combination of the total transmitter power and the degree of priority associated with the respective connections, an improved system stability can be achieved on a short term as well as on a long term basis. This example embodiment ~~of the invention~~ allows for a more sophisticated power control mechanism and a more "fair" power distribution.

The power control of the invention is thus preferably performed using the above-described power control parameters $p_{i,max}$, $\pi_{inc,i}$ and Δ_i. Hereby, one single control parameter or, alternatively, a combination of two or all control parameters can be used for a particular power control situation. There may also be example embodiments ~~of the invention~~ where the power control is effectuated through other power-related parameters, including other parameters directly or indirectly related to a power change rate of the connection-specific transmitter power.